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DRAWINGS ATTACHED

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(54) IMPROVEMENTS IN OR RELATING TO HEAT EXCHANGERS

(71) We, CENTRE SCIENTIFIQUE ET TECHNIQUE DU BATIMENT, a French Body Corporate, of 4, Avenue de Recteur Poincarre, Paris 16°, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to apparatus for exchanging heat between air extracted from a building and fresh air admitted thereto.

For reasons of hygiene and comfort a minimum amount of air renewal must be effected in buildings occupied by people or animals, whatever be the external ambient conditions. This renewal must, however, for economic reasons, be limited, to an extent determined by the nature of the occupation of the building during periods when the external conditions necessitate either heating or cooling of the building. The difficulty of obtaining suitable conditions with natural ventilation has resulted in the development of controlled ventilation which can comprise just the controlled extraction of stale air (the input of fresh air occurring in a natural or semi-natural way in each building), but may comprise also, and is expected to comprise to an increasing extent, the mechanical blowing in of fresh air, the advantages of which will be apparent. The possibility exists of centrally treating the fresh air: e.g. by humidification, removal of dust, and ionisation with the closure of local ventilation openings.

As soon as such extraction and blowing systems are used, the economic advantages of recovering heat or cold from the extracted air by the fresh air is apparent. Experiments have shown, moreover, that such recovery may be sufficient to justify economically the installation of an extraction and blowing mechanism in numerous cases.

The problem thus arises of exchanging heat between:

a) extracted air at 15—30°C and of a hygrometrical degree (humidity) between 0 and 100%,

b) fresh air the temperature of which varies according to the season and climatic zones from −25°C to +35°C and whose hygrometrical degree (humidity) varies from 0 to 100%.

It is absolutely essential that there shall be no recirculation of odours or impurities which thus excludes any contact between the two air flows. It is advantageous, on the other hand, to ensure continuous operation of the heat exchange device used so that it must be possible to use it even in a very cold period which necessitates the presence of an efficient de-icing or defrosting device. Power consumption should also be low.

There are many kinds of heat exchangers available for use over all ranges of temperature and with various exchange media. In the envisaged field of application, various solutions have already been suggested.

However the prior art suffers from various disadvantages. It is an object of the invention to improvements on the prior art.

According to the present invention there is provided a device for exchanging heat between the air extracted from a building by mechanical ventilation and the fresh air coming from the outside of the building which is admitted thereinto, wherein the extracted air and the fresh air circulate in cross current flow in an exchanger formed by a stack of plates assembled in pairs with a said plate engaging an upper adjacent said plate by two of its opposite edges and a lower adjacent said plate by its two other opposite edges, thereby to present between said engaged plates two cross fluid passages, each plate being shaped to offer an exchange surface comprising on one face a first series of studs in contact with a series of corresponding studs of an upper adjacent plate and on the other face a second series of studs offset with respect to the first series of studs, the said second series of studs being in contact with a series of corresponding studs of a lower adjacent plate.

In order that the invention may be more readily understood reference will now be made to the accompanying drawings which are given by way of example and in which:

Figure 1 shows a perspective view of a heat exchange device according to the invention.

Figure 2 shows a plan view of an exchanger according to the invention,

Figure 3 shows a section through the exchanger along the line III—III of Figure 2,

Figure 4 shows a sectional view of the exchanger along the line IV—IV of Figure 2,

Figure 5 shows a view in section along the line V—V of Figure 2,

Figure 6 shows a perspective view of one embodiment of an exchanger member,

Figure 7 shows a perspective view of one embodiment of an exchanger formed from a plurality of members,

Figure 8 shows a plan view of an exchanger comprising a deflector member,

Figure 9 shows a plan view of an exchanger incorporating a defrosting device including electrical-resistance heating means,

Figure 10 shows a plan view of an exchanger incorporating a defrosting device including a radiator connected to the heating circuit of a building,

Figure 11 shows a plan view of an exchanger showing the area at which frosting could occur,

Figure 12 shows a plan view of an exchanger provided with a defrosting device having a movable shutter or valve,

Figure 13 shows a plan view indicating bypassing of the shutter,

Figure 14 shows a perspective view of an exchanger including a defrosting device using a brine flow,

Figure 15 shows a plan view of a device for varying the load of the exchanger.

Figure 16 shows a perspective view of an embodiment of a heat exchange installation according to the invention,

Figure 17 shows a view in section of the installation at the input side for the fresh air, and

Figure 18 shows a detail of the installation at the input side for the extracted air.

Referring now to the drawings, one embodiment of an exchanger according to the invention is shown in Figures 1, 2, 3, 4 and 5, wherein the air extracted from the building is circulated in the direction of the arrow A, and the fresh air is circulated in the direction of the arrow B, or vice versa, in order to obtain cross-current circulation of the two fluids in an exchanger on both sides of the stacked plates 1 of the exchanger.

The exchanger is formed by a stack of plates such as 1*a*, 1*b*, 1*c*, 1*d* joined in pairs at their edges 2 and 3, for example by edge-beading 11, to offer openings 4 and 5, for the cross passage of the two air streams in the directions of the arrows A and B.

Each plate such as 1*b* is shaped to offer an exchange surface 6 having on one face a first set of studs 7*b* in contact with a set of corresponding studs 7*a* an an upper adjacent plate 1*a* so as to provide passages 8 between the two plates, e.g. 1*a* and 1*b*, for one of the fluids, more particularly the air extracted from a building.

The plate 1*b* is shaped to offer on its other face a second set of studs 9*b* offset in two right angled linear directions *i* and *j* with respect to the first set of studs 7*b*. This second set of studs 9*b* is in contact with a set of corresponding studs 9*c* on a lower adjacent plate 1c so as to provide passages 10 between the two plates, e.g. 1*b* and 1*c*, for the other fluid flow, more particularly for fresh air.

An exchanger of this type is formed by a stack 12 of plates 1*a*, 1*b*, 1*c* assembled in the manner described above to form an exchanger member 13 as shown in Figure 6. To this end, and as shown in Figures 1 and 2, indentations 14 are provided on the four corners of the plates to receive upright members 15 (shown only in Figure 6 and in phantom in Figure 1) formed by angle irons or stakes which are fixed by their ends to two rigid plates 16 and 17 to form an exchanger member.

An exchanger such as 18 shown in Figure 7 may comprise a suitable number of exchanger members 13 stacked to provide the desired exchange area according to the volume of fluid to be treated. The exchanger members 13 are assembled together by detachable frames 19 and 20.

Examination of the configuration of the exchangers shows that the area of the plates most distant from the fluid inputs is that where the least heat transfer is effected (Figure 8). Consequently, it is possible to improve the heat exchange appreciably by modifying the flows in this area 21. To this end, deflectors 22 are provided which block certain of the passages.

The field of application of the exchanger described, as regards the temperature and nature of the media which flow over its plates, is such that either metals or plastics materials can be used for its manufacture.

In the case of plastics materials, sheets or thin plates are used which are capable of being formed as hereinafter described, the thickness of the material used being the thinnest compatible with the desired mechanical resistance: for example, a thickness of 0.17 mm is sufficient when using a cellulose acetate polymer. The plastics materials forming the plates are suitably treated e.g. anti-statically, to reduce their dirtying by the extracted air and the fresh air if the dust

normally contained therein has not been removed therefrom.

Examples of plastics materials which may be used for the plates, are cellulose acetate, cellulose acetobutyrate, cellulose propionate, polyvinylchloride or vinyl copolymers, polystyrene, butadiene styrene acrylonite, high density polyethylene, polypropylene, polymethylpentene, polymethylmethacrylate, butadiene styrene methacrylate or polycarbonate.

These materials may be formed to the required shape by the method desired, for example by cold stamping, by hot stamping, by hot vacuum forming, by hot forming, by blowing or by continuous calendering over studded cylinders.

Adhesion of the plate edges may be carried out with the aid of a solvent or hardening adhesive. It may also be possible to weld the plate edges with or without the addition of material.

Where metals are used for making the plates, thin sheets thereof may be formed by stamping, forming, calendering or embossing.

If desired, the plates may be protected by being coated with a plastics material of any desired and suitable kind.

With an exchanger of this type, it is possible to use one of a number of de-icing or defrosting devices selected according to the relative frequency of low external temperatures, the size of the installation and energy recovery.

In a first device, preheating of the fresh blown in air is effected upstream of the exchanger so as to keep the air above a temperature To, which is a critical temperature below which disturbances due to frosting are possible for the particular application envisaged. (For dwelling places, To is not greater than −5°C; this can be less if the hygrometric degree (humidity) of the extracted air is small or if this air contains pollutants.)

As shown in Figure 9, there is arranged in the conduit 23, an electric heating resistor 25, whose operation is controlled by a thermostat or modulator 26 whose temperature controlling member 27 is located in the conduit 23 between the resistor 25 and the exchanger 24.

In a large installation, fine regulation is preferable to an on-off thermostat. The necessary heating power of the resistor is calculated having regard to the air flow to be treated, the temperature To and the data concerning the lowest ambient temperatures which occur at the place where the apparatus is installed.

There is shown, in Figure 10, a device wherein a heating radiator 28 is arranged in fresh air conduit 23, upstream of the exchanger 24. This radiator 28 is connected in parallel to the circuit 29 of the heating installation of the building by means of a butterfly valve 30 controlled by a thermostat or modulator 31, the temperature-sensing member 32 of which is located in the conduit 23 between the radiator 28 and the exchanger 24. (In this case it is necessary to take precautions at the radiator 28 against icing or freezing of the liquid which the radiator contains).

As indicated in Figure 11, condensation, then frosting can appear in the zone 33 where the extracted air directed according to the arrow B is at its coolest.

It is possible to avoid this phenomenon by locally limiting the cooling by modifying the flow of fresh air, as is shown in Figure 12, by means of a movable shutter 34 capable of moving as indicated by the double arrow in the fresh-air conduit 23. The position of the shutter 34 is controlled by the temperature of the fresh blown air upstream of the exchanger by means of a regulating member 35 which ensures movement of the shutter in dependence upon the temperature sensed by the sensing gauge 36.

It is necessary for the shutter 34 to be situated very close to the input edge of the exchanger so as to prevent the air travelling via gap 37 between the shutter and the plates of the exchanger 24, which travel would render the device inefficient (see Figure 13).

In any embodiments, when the temperature of the fresh air is lower than T*o*, a suitable medium can be added to the air by atomisation to lower the freezing point of any condensable vapour it contains to below the coldest temperatures which it is possible to encounter. However such a solution is only feasible in large installations. For instance the air being treated from factories may contain a suitable medium.

Figure 14 shows another embodiment of a defrosting device wherein the plates of the exchanger 1 are arranged in an inclined manner so as to allow brine to trickle over the plates on the air extraction side. A heater 38 for the flow of the brine which has a low freezing point is arranged over the upper part of the plates and the brine collecting reservoir 39 is situated below their lower parts.

The circulation of the liquid or brine is effected by a pump 40 controlled by a member 41 for measuring the outside temperature. It is, moreover, possible to operate this trickling continuously, which may provide for continuous cleaning of the plates of the exchanger. Steps should be taken, however, to prevent corrosion of the plates by the liquid.

This device can be used in installations dealing with large air flows in a cold climatic zone.

Another method of defrosting is shown in Figure 15 wherein variation in the load on the exchanger is utilised.

In this case, a parallel conduit 42 is used which enables the flow of fresh air issuing from the conduit 23 to be diverted and to bypass the exchanger 24 for given periods.

The device also comprises a register 43 which enables the opening of the shunt conduit 42 to be controlled, the said register 43 being actuated by a control device 44 of the electronic or electromechanical type which is connected to a member 45 for sensing the outside temperature.

Regulation is obtained by cutting out the device in dependence upon the outside temperature.

The heat exchange device may conveniently comprise a fan for blowing fresh air, a fan for extracting air, an exchanger formed by a stack of plates, a defrosting device if the climatic conditions require it, and, if desired, filters in the extraction and blowing circuits.

The size of the exchanger device depends on the air flow to be treated.

According to the volume of flow to be treated, two separate devices may be used together.

Figures 16, 17 and 18 show a heat exchanger apparatus suitable for an individual house which caters for air flows of the order of 200 to 600 m³ per hour.

The apparatus comprises a metal support 46 on which one or more exchanger members 47, as hereinabove described with reference to Figure 6, are mounted in an inclined fashion. To the side of the exchanger, two chamber members 48 and 49 are arranged one of which has an orifice 50 and the other a fan 51.

In the lower part, the apparatus comprises a chamber member 52 for the air extracted from the building which has an air input orifice 53 and in its upper part a chamber member 54 provided with a fan 55 for the evacuation of the extracted air which is connected to the outside by connecting conduits.

The plates of the exchanger are inclined so as to facilitate natural flowing of condensation water; a gutter 59 is arranged at the bottom of the member 52 to receive this water whence it is directed through an orifice 58 to a cleaner (Figure 18).

Pre-heating is effected by a heating electric resistor 56 the operation of which is controlled by a thermostat 57 (Figure 17).

WHAT WE CLAIM IS:—

1. A device for exchanging heat between the air extracted from a building by mechanical ventilation and the fresh air coming from the outside of the building which is admitted thereinto, wherein the extracted air and the fresh air circulate in cross current flow in an exchanger formed by a stack of plates assembled in pairs with a said plate engaging an upper adjacent said plate by two of its opposite edges and a lower adjacent said plate by its two other opposite edges, thereby to present between said engaged plates two cross fluid passages, each plate being shaped to offer an exchange surface comprising on one face a first series of studs in contact with a series of corresponding studs of an upper adjacent plate and on the other face a second series of studs offset with respect to the first series of studs, the said second series of studs being in contact with a series of corresponding studs of a lower adjacent plate.

2. A heat exchange device as claimed in claim 1, wherein the exchanger is formed from a plurality of said stacks of plates.

3. A heat exchange device as claimed in claim 1 or 2, wherein air deflector members are disposed in the said passages.

4. A heat exchange device as claimed in claim 1, 2 or 3, wherein the plates are produced from shaped sheets of a plastics material.

5. A heat exchange device as claimed in claim 4, wherein the plates are made from cellulose acetate anti-statically treated to limit its dirtying by the extracted air and any input air that has not been freed from dust.

6. A heat exchange device as claimed in claim 4, wherein the plates are made from polyvinylchloride and vinyl copolymers anti-statically treated to limit its dirtying by the extracted air and any input air that has not been freed from dust.

7. A heat exchange device as claimed in claim 4, wherein the plates are made from polystyrene anti-statically treated to limit its dirtying by the extracted air and any input air that has not been freed from dust.

8. A heat exchange device as claimed in claim 4, wherein the plates are made from butadiene styrene acrylonitride anti-statically treated to limit its dirtying by the extracted air and any input air that has not been freed from dust.

9. A heat exchange device as claimed in claim 1, 2 or 3 wherein the plates are produced from shaped metal sheets.

10. A heat exchange device as claimed in any of the preceding claims which comprises means for linking the exchanger to respective air blowing and extracting fans and means for treating the air.

11. A heat exchange device as claimed in claim 10, which further comprises means, located upstream of the exchanger, for pre-heating the fresh air.

12. A heat exchange device as claimed in claim 11, wherein the means for pre-heating the fresh air are formed by an electric heating means controlled by a thermostat.

13. A heat exchange device as claimed in claim 11, wherein the means for pre-heating the fresh air are formed by a heating radiator connected to a heating installation of the building.

14. A heat exchange device as claimed in any of claims 10 to 13 comprising a movable shutter of which the position in the said means for linking the exchanger is controlled by the temperature of the fresh air.

15. A heat exchange device as claimed in any of the preceding claims wherein means are provided for spraying a medium whose presence in condensable vapour in the air has the effect of lowering the freezing point thereof.

16. A heat exchange device as claimed in any of the preceding claims wherein brine is caused to flow by gravity over the plates of the exchanger on the air extraction side, the circulation of which is effected by a pump operating in a manner controlled by the outside temperature.

17. A heat exchange device as claimed in any of the preceding claims wherein there is provided, in parallel with the exchanger, a conduit for the fresh air, having an orifice which is controlled by a register controlled from a regulation device in dependence upon the temperature of the outside air.

18. A heat exchange device, substantially as hereinbefore described with reference to the accompanying drawings.

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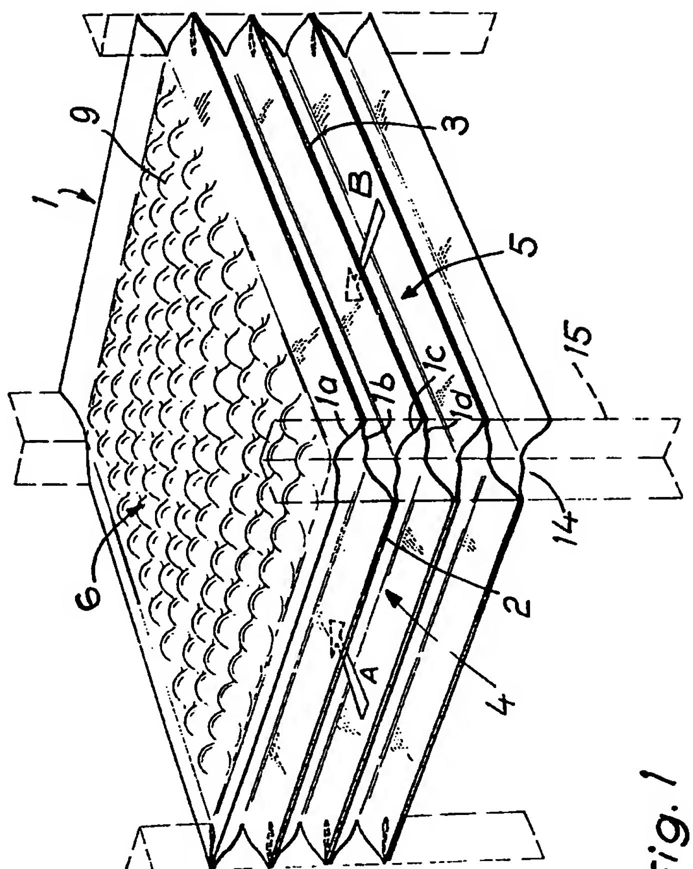

Fig. 1

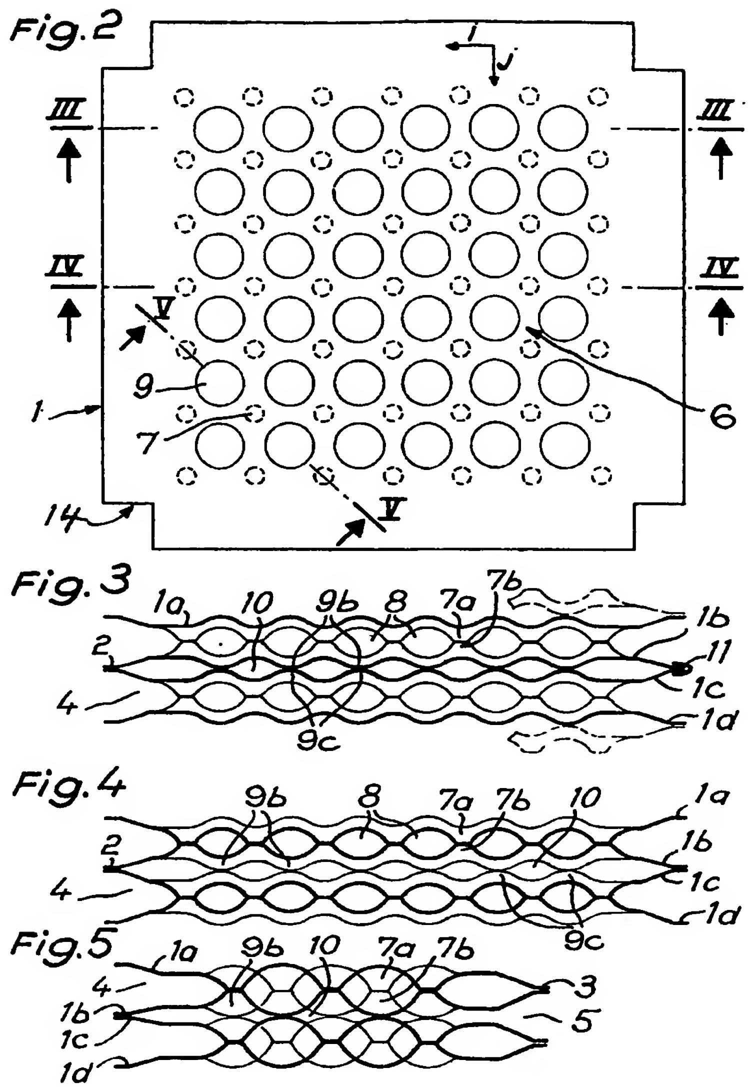
Fig. 2
III
IV
V
I
J
1
6
7
9
14
Fig. 3
1a
10
9b
8
7a
7b
1b
2
11
1c
4
1d
9c
Fig. 4
9b
8
7a
7b
10
1a
2
1b
1c
4
1d
9c
Fig. 5
1a
9b
10
7a
7b
4
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1b
5
1c
1d

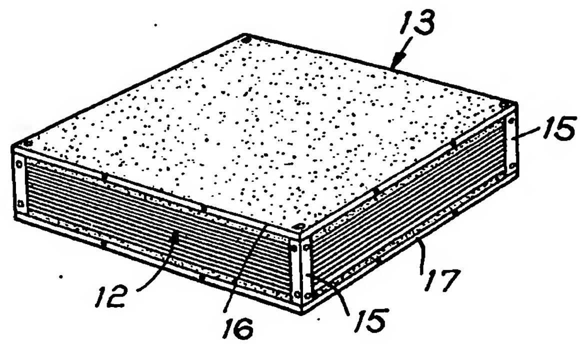


Fig. 6

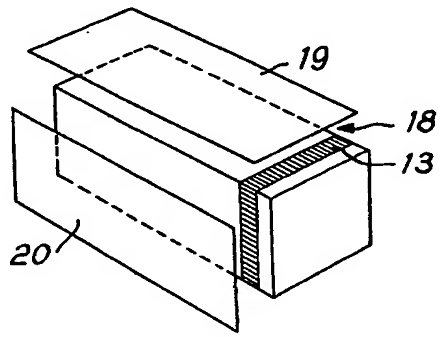


Fig. 7

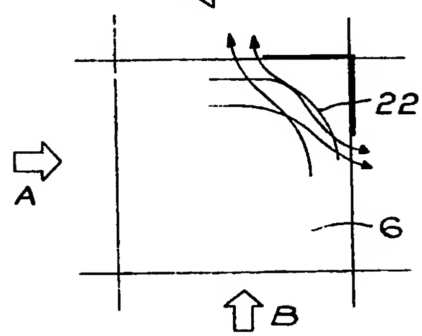


Fig. 8

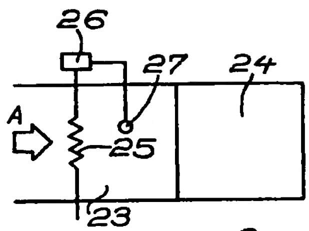


Fig. 9

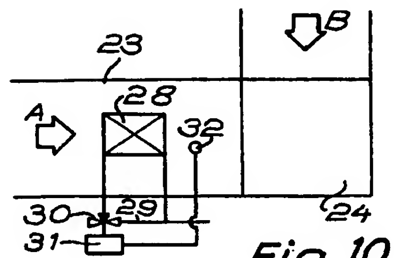


Fig. 10

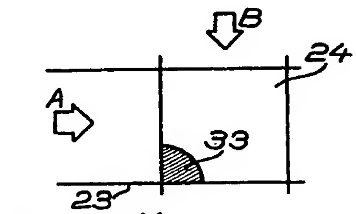


Fig. 11

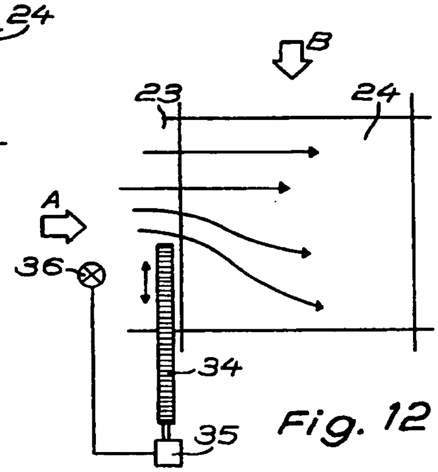


Fig. 12

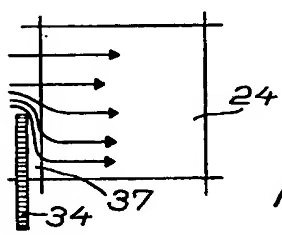


Fig. 13

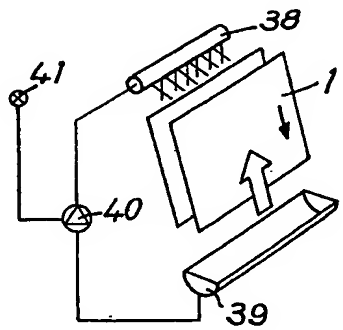
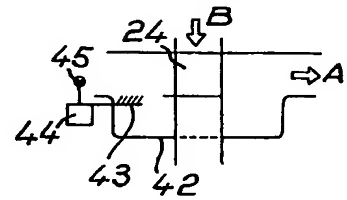


Fig. 14

Fig. 15



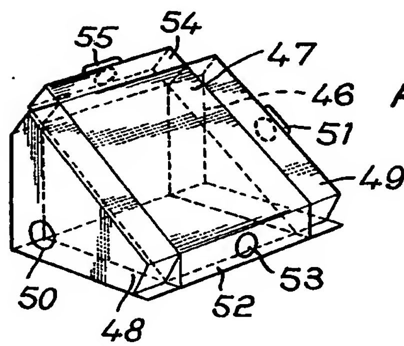


Fig. 16

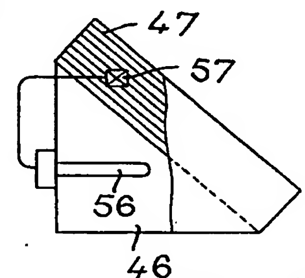


Fig. 17

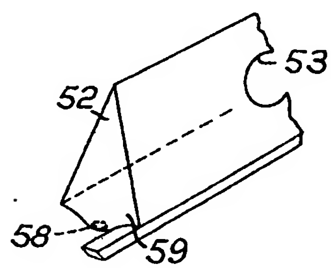


Fig. 18